Ethical Issues Invoked by Industry 4.0

Harjinder Rahanu[1], Elli Georgiadou[1], Kerstin Siakas[2,3], Margaret Ross[4], Eleni Berki[5]
[1]Middlesex University London, London, UK
harjinder2@mdx.ac.uk, elli.georgiadou@gmail.com
[2]International Hellenic University, Thessaloniki, Greece
[3]University of Vaasa, Finland, siaka@ihu.gr
[4]Solent University, Southampton, UK, margaret.ross@bcs.org.uk
[5]University of Jyväskylä, Finland, eleni.e.berki@jyu.fi; eleniberki1@gmail.com

Abstract. Industry 4.0 is universally referred to as the fourth industrial revolution. It is a current trend of automation and data exchange in manufacturing technologies. The computerisation of manufacturing includes, amongst other, cyber-physical systems, the Internet of Things (IoT), cloud computing and cognitive computing. There are many challenges in the realisation of Industry 4.0. In order to adopt a "smart factory" and improved (software) processes many ethical considerations need to be identified and considered if a company is to obtain an ethical development and deployment of Industry 4.0. The purpose of normative ethics is to scrutinise standards about the rightness and wrongness of actions, the ultimate goal being the identification of the true human good. A rational appeal can be made to normative defensible ethical rules in order to arrive at a judicious, ethically justifiable judgement.

In this position and constructive design research paper our steps are: First we report on the findings of a broad literature review of related research, which refers to the current challenges in the realisation of Industry 4.0. Second, we identify and list some basic generic Deontological and Teleological ethical principles and theories that can serve as normative guidelines for addressing the challenges identified in the initial step. Third, we prescribe a set of ethical rights and duties that must be exercised and fulfilled by protagonists/stakeholders in Industry 4.0 implementation in order for them to exhibit ethical behaviour. Each of these suggested actions are substantiated via an appeal to one, or a number of the normative guidelines, identified in the second step. By identifying and recommending a set of defensible ethical obligations that must be fulfilled in the development and deployment of smart factories, protagonists such as: employers, project managers, technology suppliers, trade unions, (on a microscopic level) and chambers of commerce, local and national government (on a macroscopic level) and other can fulfil their ethical duties. Thus, a deployed Industry 4.0 solution can result in technological change, social change and changes in the business paradigm, which are all ethically justifiable. Ultimately all the improvement processes of Industry 4.0 implementation must be underpinned with ethical consideration

Keywords: Normative Ethics, Industry 4.0, Cyber-Physical Systems

1 Introduction

Industry 4.0 (i4.0) is viewed as a subset of the fourth industrial revolution. The terms *Industry 4.0* and *fourth industrial revolution* are often used as synonyms but it should be noted that the former has a focus on industry where *smart* factories have machines which are augmented with wireless connectivity and sensors, connected to a system that can visualise the entire production line and make decisions independently [1]. Past industrial revolutions include the: 1st Industrial Revolution, end of the 18th century, which ushered in mechanical production, railways and the steam engine; 2nd Industrial Revolution, beginning of the twentieth century, characterised by mass production, powered by electricity and assembly line; and the 3rd Industrial Revolution, 1970s decade, overseeing the exploitation and development of computers, semiconductors, main frame computing, personal devices and the internet [2]. The 4th Industrial Revolution, including Industry 4.0 or *smart factory*, represents the current trend of automation technologies in the manufacturing industry. It is enabled by a host of technologies that can be summarized into four major components: Cyber-physical systems (CPS); Internet of Things (IoT); Cloud and Cognitive computing [3] and [4].

With this digital transformation there is a fundamental need for assisting companies in the transition to Industry 4.0 technologies/practices and guiding them for improving their capabilities in a standardized, objective, and repeatable way. In [5] the authors argue that comprehensive guidance can

be provided by the adoption of an Industry 4.0 Maturity Model, which is a "*holistic approach consisting of the assessment of process transformation, application management, data governance, asset management, and organizational alignment areas*". Such a model facilitates a common base for performing an assessment of the establishment of Industry 4.0 technologies, and to guide companies towards achieving a higher maturity stage in order to maximize the economic benefits of Industry 4.0. Basically, it provides standardization in continuous benchmarking and improvement of businesses in the manufacturing industry.

Any guidance provided through the adoption of specific models, e.g., Industry 4.0 Maturity Model or certain methodologies, such as Software Process Improvement (SPI) that plan and implement improvement activities to achieve specific goals, e.g. increasing development speed, achieving higher product quality or reducing costs, must do so in a legal and an ethical manner. This paper focuses on the argument for the latter. Any deployment will inevitably invoke technological and social changes as well as shifts in the business paradigms, ultimately impacting on the lives of people (users, employees, consumers and citizens). Thus, careful ethical considerations must be taken in any project involving the automation of manufacturing industry.

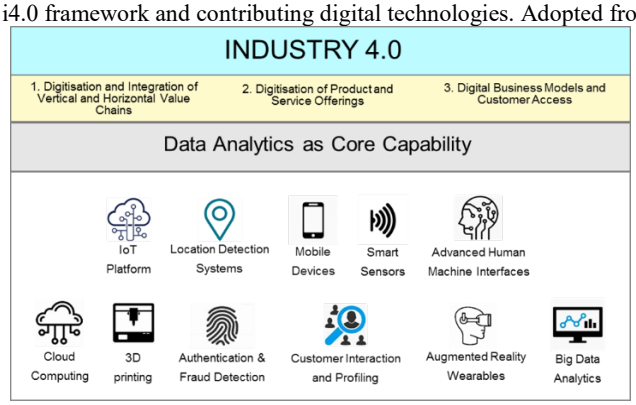
As with each and every phase of the industrial revolution since the harnessing of steam, these cutting-edge innovations will change the way we live and work forever. Thus, careful consideration must be taken in how the development and deployment of technological innovation impact on the worker and society at large. Varoufakis observed that at the end of the 18th century it was the technology of cogs and wheels of machinery, which posed the greatest challenge and disruption to "*the rhythms and routines of feudal life*" [6]. This mechanical production that was driven by steam power swept the peasantry, unwillingly, moving them to work in the factories. Rolling forward two centuries the world is facing enabling technologies that can automate manufacturing, *smarten* factories which, with unfettered checks, could lead to troublesome, unanticipated consequences for the worker. Marx eloquently stated: "*The bourgeoisie cannot exist without constantly revolutionising the instruments of production, and therefore the relations of production, and with them the whole relations of society*" throwing the worker and wider society in "*everlasting uncertainty and agitation*" [7]. Therefore, the development and quality deployment of i4.0 technologies must be driven by, and permeated with, ethical considerations so that social uncertainty and agitation are, if not fully averted, at least minimised.

1.1 The Four Design Principles and Technologies in Industry 4.0

Industry 4.0 is underpinned by four core design principles [3]. **Interconnection**: The ability of components: machines, devices, sensors, and people to connect and communicate with each other through the Internet of Things (IoT) or the Internet of People (IoP). **Information transparency**: Transparency provides operators with copious useful information, from all points in the manufacturing process, which aids them in the decision-making process. This helps functionality and permits the identification of key areas that can benefit from innovation and improvement. **Technical assistance**: Assistance systems support operators through the ability to aggregate and visualise information comprehensively. Also, cyber physical systems (such as robots) have the ability to physically support humans by performing a range of tasks that maybe unpleasant, too exhausting, or unsafe for their human colleagues. **Decentralized decisions**: The capability of cyber physical systems to make decisions independently and to perform their tasks as autonomously as possible. However, tasks are delegated to a higher authority in the case of exceptions, interferences, or conflicting goals. These four notions typically support manufacturing companies in identifying and implementing i4.0 scenarios. Contributing digital technologies which enable i4.0 are presented in Figure 1, below [8], [9], [10] and [11].

The *digitisation and integration of vertical and horizontal value chains* is core to defining what i4.0 is [11]. The former involves processes vertically across the whole organisation from "*product development and purchasing, through manufacturing, logistics and service*". Aided by augmented/virtual reality and an integrated network, all the data concerning operations processes, process efficiency and quality management and operations planning are available in real-time. The latter is enabled via the utilisation of technologies, e.g., track and trace devices to real-time integrated planning with execution, allowing the seamless connection of suppliers to customers and all key value chain partners.

Fig. 1. i4.0 framework and contributing digital technologies. Adopted from [11].



Industry 4.0 is driven by *the digitisation of product and service offerings*. Using technologies such as smart sensors or communication devices that can be used with data analytics tools companies are able to generate data on product use and refine products to meet the increasing needs of end-customers. This ultimately implies that a business can have an expansion of existing products as well as the creation of new digitised products which focus on completely integrated solutions. The expansion of offerings is provided through using *digital business models and customer access*. This is achieved by providing disruptive digital solutions such as complete, data-driven services and integrated platform solutions. The focus of such models is to generate additional digital revenues and optimise customer interaction and access. Digital products and services frequently look to serve customers with complete solutions in a distinct digital ecosystem.

1.2 Industry 4.0 and the Software Process Improvement Manifesto

The elements that define Industry 4.0 are fundamentally based on software, and each and every one of these elements must be managed with effective processes. In [12] the author argues that during the software design and development, many wasting problems are encountered and the software process is adversely affected. It is further argued that to be able to adapt to the industry 4.0 environment and furthermore, it is necessary to have low costs, efficient and lean processes, flexible environments to survive the competition. This could be achieved, for example, by adopting lean and agile approaches in the Implementation phase of the software process, resulting in improved processes for the companies and their managers who are engaged in completing the software project.

Principles and values from both the Agile and SPI Manifestos seemed to influence and transform the mindsets of the modern and/or traditional software development teams, with the purpose of enabling them to provide rapid and at the same time disciplined and acceptable deliverables. For instance, lack of conceptual clarity in the one paradigm could lead to teams interpreting and implementing agile/traditional values variously and not uniformly [14]. Thus, it might be the correct time to consider a unified paradigm which could encapsulate the strengths of both the Agile and the SPI paradigms that could facilitate the transition to i4.0 for the process and product quality within ethical parameters.

In evolutionary software development, the Software Process Improvement (SPI) is founded on the belief that a well-defined and executed process is likely to produce a high-quality product, its Manifesto's principles guiding the behaviour of individuals, groups, and organisations in their efforts to improve process [13]. In [15] the authors present a STEEPLED (Social, Technical, Economic, Environmental, Political, Legal, Ethical and Demographic) analysis of the SPI Manifesto allowing for strengths, gaps and the impact to be assessed. The analysis suggested, amongst other things, that the three values and 10 principles of the SPI be imbued with ethical duties and rights. In doing so, this public pledge not only adheres to legal rights and duties but also ethical responsibilities and entitlements. Therefore, any development of Industry 4.0 elements, aligning with the concepts outlined in the SPI Manifesto, must at its very core consider the ethics of and for people, business focus and organisations in their efforts to improve process.

1.3 Computer Ethics

The study of computer ethics can be viewed as: "*.... The study of the ethical questions that arise as a consequence of the development and deployment of computers and computing technologies.*" [16]. It is generally recognised that law and ethics do have in common certain key principles and obligations.

Thus, the law will clearly apply and lead directly to the appropriate ethical conclusion. However, to rely solely on law as an ethical guideline is clearly dangerous because in certain circumstances bad laws exist [17] and [18]. Inadequate laws may bind rules on society that fail to provide ethical guidance. Such laws may, in some instances, excuse a society from fulfilling certain obligations and duties, or allow a society to justify their unethical behaviour. Ethical judgments simply do not have the same deductivity and objectivity as scientific ones. However, such judgments should be based upon rational ethical principles and sound, carefully reasoned arguments. Normative claims are supported by: "*An appeal to defensible moral principles, which become manifest through rational discourse*" [18]. A normative claim can only be substantiated, and a rational discourse presented, through an appeal to such principles. Thus, with regard to the ethical issues raised by the development and deployment of i4.0, in Section 2 of this paper we will present our methodological framework of thinking. The latter is an applied research method which includes a list of defensible ethical principles that are taken from ethical theory utilised also as the method for conducting an ethical analysis. In Section 3 the authors identify the current issues concerning i4.0. The effects, challenges and impacts of i4.0 will be identified. A number of heuristics are suggested in Section 4 which, if systematically followed, could lead to ethical guidance concerning design principles, components and technologies that underpin and are utilised by i4.0. These normative claims are substantiated via the citation of one or a number of the ethical principles from Section 2. Thus, each heuristic is based upon rational, ethical and philosophical principles, and upon carefully reasoned arguments.

2 Research Methodology: Constructive Design Research

2.1 Method for Conducting an Ethical Analysis

In [17] the authors present a method for conducting an ethical analysis. This method has been adapted and will be adhered to in order that an ethical analysis of the issues invoked by i4.0 can be completed. The completion of the analysis will result in a set of heuristics, which can be used as the means for advancing our understanding of the impact of i4.0 on workers and wider society and suggesting ways of reaching wise and ethically acceptable solutions to these problems. The logically related steps that will be taken in order that an ethical analysis of i4.0 can be completed comprise four steps. These are: **Step 1**: List the effects/challenges/impact of Industry 4.0; **Step 2**: Identify the stakeholders (those affected by the issues raised in Step 1; **Step 3**: Identify stakeholder obligation/duty to do, or not to do, something; and **Step 4**: Apply normative ethical principles.

For the first task the effects, challenges and impact of Industry 4.0 will be identified via a literature review. Therefore, several papers were analysed in accordance with i4.0 and its effects, challenges and impact. The databases that were accessed in order to retrieve the literature included: Emerald Insight, Science Direct, IEEE Xplore and Google Scholar, which presents the most cited articles related to the field. By searching for keywords such as: *Industry 4.0*; *Smart Factories* and *Industrialised IoT* a total of 20 papers were collected. In order that the most up to date, contemporary information is sourced the journals selected were published in the period between 2017-2020. After the analysis of these papers, seven were selected for describing the effects, challenges and impact of Industry 4.0 [Task 1] and listing stakeholders [Task2] as required for conducting this ethical analysis. The stating of such facts is, "*as much as possible, a neutral, logical exercise*" [17]. Interpretation is involved in selecting pertinent facts but they are not judged during this step. This judgement process is presented in Section 3.1, below. The second task is to list the stakeholders in the case to determine who is affected by the action being analysed. In this analysis stakeholders affected by the effects, challenges and impact of Industry 4.0 as identified in the previous step of the methodology, will be recorded. A judgement must be made as to whether a (primary) stakeholder is important enough to be listed. There may also be a number of (secondary) stakeholders but including them and their claims might not improve the depth of the case analysis. This is presented in Section 3.2, below.

It is necessary to consider whether stakeholders were or are under an obligation or duty to have done or not have done something [Task 3]. In order to identify these duties, a framework presenting a set of generic traditional ethical concepts could be used to flag potential ethical obligations, in a given case [19]. These are: 1) Quality of life; 2) Use of Power; 3) Risks and reliability; 4) Property Rights; 5) Privacy; and 6) Equity and Access. Summaries of each of these six traditional ethical concepts are presented in Section 3.3. These concepts helped computer professionals think about their ethical duties in the development and deployment of computing technology. These are generic and are applicable to all humans, in all contexts and cases, to help realise what their ethical duties are in everyday life. The

application of these ethical concepts and the resulting derived obligations are presented in Section 3.3, below. Finally, having established one or more of the courses of actions for each stakeholder, one or a number of normative ethical principles are cited in order to substantiate the course of action(s) that should be taken in order to fulfil ethical obligations [Task 4]. This is presented in Section 4, below.

2.2 Normative Ethical Principles

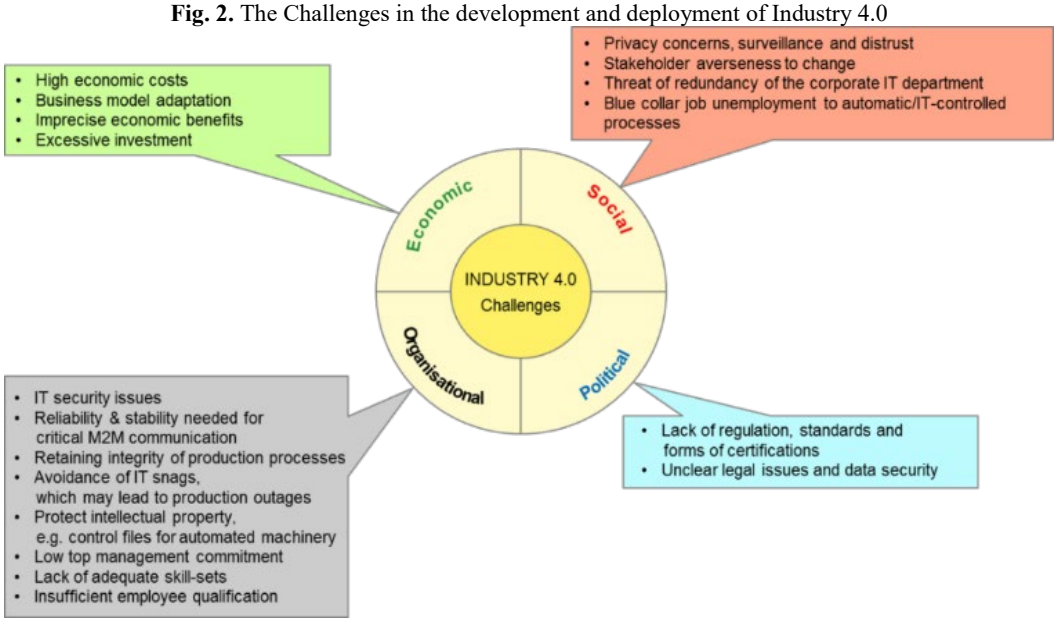
Fundamentally, there are two basic approaches to ethics: *Teleological* theories (consider the consequences of an action as a measure of goodness) and *Deontological* theories (emphasise the rightness of an action above the goodness it produces). These theories list some basic ethical principles that can serve as normative guidelines for addressing the ethical issues, cases where ethical and professional issues may have been invoked [17]. These principles have been sourced from ethical theories, including Teleological and Deontological ones. Further normative principles, sourced from Kantian ethics, are also offered. In [20] the authors give definitions and detailed summaries of each normative ethical principle.

3 Ethical Analysis

3.1 Step 1: Effects/Challenges/Impact of Industry 4.0

In accordance to the methodology described above the analysis of seven selected papers permitted the identification of the challenges that are faced in the development and deployment of Industry 4.0, as presented in Figure 2. The analysis of the literature suggests that the challenges can be categorised as a class/cluster of one of the following four types: Economic, Social, Political and Organisational [21], [22], [23], [24], [25], [26] and [27].

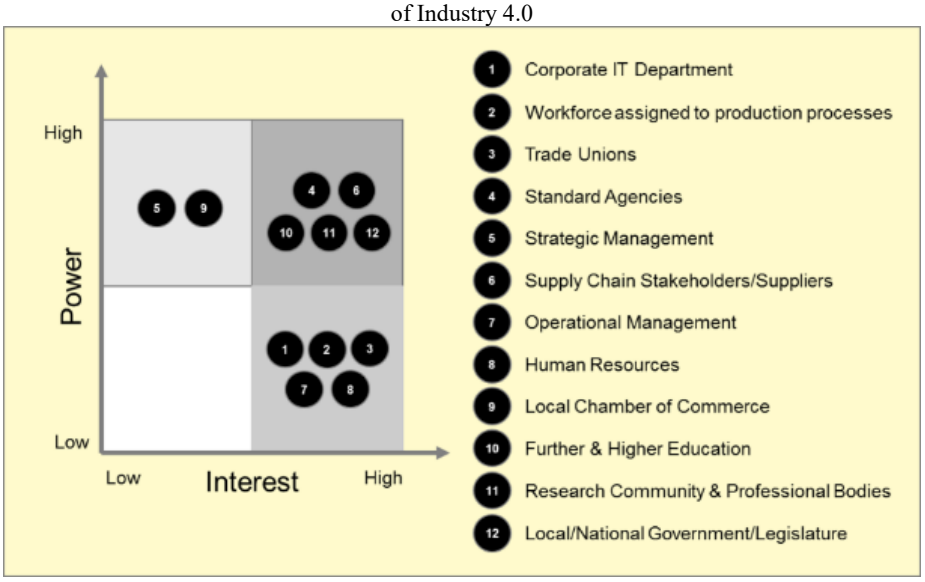
Fig. 2. The Challenges in the development and deployment of Industry 4.0



3.2 Step 2: Stakeholders in Industry 4.0

A judgement as to whether a stakeholder is important enough to be listed is determined by the results of the analysis of the literature, which suggests that there are a number of stakeholders that are affected by the development and deployment of i4.0 [21], [22], [23], [24], [25], [26] and [27]. A power-interest grid, which considers stakeholder power and expectations, therefore their likely interest(s), can be used to determine and present the potential influence of stakeholders groups [28]. This model, see e.g. Figure 3, was developed in order to present the stakeholders in Industry 4.0.

Fig. 3. A Mendelow power-interest grid presenting the stakeholders affected by the development and deployment of Industry 4.0



3.3 Step 3: Stakeholder Obligations

In this final step of the ethical analysis of Industry 4.0 it is necessary to consider whether stakeholders groups, as identified above, were or are under an obligation or duty to have done or not have done something. The emphasis here is on simply identifying course(s) of action(s) that a stakeholder is required to take and (which) can be viewed as constraints on them that limit the exercising of certain freedoms. The people, who are under obligations, may choose to freely act under obligations [29]. The obligations are not considered in the context of specific legal, social, religious, political or legal norms. The application of the six traditional ethical concepts [19] were applied to assist in the identification of these obligations. A non-exhaustive list of Stakeholders, the moral concepts and respective obligations are presented in Tables 1- 4 below.

Table 1. A non-exhaustive list of Stakeholders and respective obligations for the Moral Concept of Use of Power

Stakeholders: 3, 5 and 12
Moral Concept: *Use of Power*

An understanding of the ethical choices that face both the powerful and the less powerful is an important step in becoming a responsible professional [19]. Thus, those stakeholders with high degree of power, as flagged in the power interest grid, Figure 5, must ensure that they are aware of their moral responsibilities to those stakeholders with less power who will be affected by the development and deployment of Industry 4.0.

Impact on Human Workers

For example, Government policies on *Innovation* and *Science & Research* are formulated in the context of *Employment Relations*. In the UK the Department for Business, Energy and Industrial Strategy have the obligation to prepare policies in these three, amongst other, areas. Thus, any industrial innovation must be understood in the context of the interrelations between employers and employees, labour/trade unions, employer organizations and the state. Similarly, in the formulation of organisational strategy decision making processes, the higher strategic management key stakeholders group(s) need to be aware of the responsibility to ensure that they are fully conscious of the impact and effects of their decisions made at the Board level and affect the lives of the workers who belong to the lower, operational level(s). These not only include the *blue-collar* workers at the coal face but also operational management and the corporate IT department, who have conventionally overseen the major IT functions of governance, infrastructure and functionality of the organisation's IT systems.

Technology substituting human worker

A core issue involved in the workflow processes of the Industry 4.0 debate is the balance between job maintenance and technological advances. This requires a continued adjustment between power relations in society and how financial returns are being distributed. Whereas proponents of the fourth industrial revolution argue that people's jobs are not going to vanish at an unprecedented rate and that in the same vain as the first three industrial revolutions (steam power, electricity, and computers, respectively) helped to expand the labour force rather than contract it, the fourth industrial

revolution will be no different. If this fourth revolution is not managed properly then shifting power will create important new security and privacy concerns and that inequalities could grow rather than shrink [30] and [31]. The example of increased automation of (human) work processes is cited where, "*computers and machines will replace workers across a vast spectrum of industries, from drivers to accountants and estate agents to insurance agents*". By one estimate, as many as 47 percent of U.S. jobs are at risk because of automation [30]. The fourth industrial revolution will benefit the rich much more than the poor, arguing that low-skill, low-wage jobs will disappear in favour of automation. From a historical perspective, industrial revolutions have always begun with greater inequality followed by periods of political and institutional change [1]. However, this moral concept demands that we must contemplate and formulate policies that, at their very core, consider all the changes a fourth industrial revolution would bring, including the inevitable major changes to the very structure of our society, in both the immediate, short and long term peoples' futures. Utilising data analytics in order to optimise resourcing, increasingly varying employee hours each week according to anticipated demand for labour, could see a growing proportion of the workforce shifted onto zero-hours contracts, leaving more individuals facing income volatility. In addition, new technologies could see a wage–productivity decoupling occurring if new technologies erode employee bargaining power in wage negotiations. If job security is perceived to be much lower in a world of rapidly advancing automation, and if workers see others made redundant as a result of automation, employees may become more reluctant to request a pay rise [31].

Table 2. A non-exhaustive list of Stakeholders and respective obligations for the Moral Concepts of Quality of Life and Equity and Access

Stakeholders: 3, 4, 8, 9, 10 and 11
Moral Concepts: *Quality of Life, Equity and Access*

Promoters of new technology do not always take into consideration the concept of *quality of life* [19] from a holistic point of view. Does faster, better, more, always equal to an increase in quality of life for the end-users or/and the stakeholders of new technology? Do the designers' and decision makers' conceptions correspond to the quality of their own and others' lives? These sentiments must be among the highest considerations of Industry 4.0 stakeholders. Likewise, careful consideration needs to be given to the extent to which modern technology has divided us into those who have access to the power of technology and those who do not. Thus computer professionals' opinions on these matters should be grounded in careful ethical reasoning about issues of equity and access in current society.

Training

The role of employees in this new fourth industrial revolution has demanded workers to possess digital skills and other competencies giving rise to the concept and development of the "Operator 4.0" [32] or the "Smart Human Resources 4.0" [33]. This transformation requires an investment in human capital [26]. Promoters of i4.0 must focus on their moral duty to produce a workforce that can have the skills and competencies in order that the worker is not thrown into, as Marx states: "*everlasting uncertainty and agitation*" [7]. Likewise, defenders of workers' rights must ensure that they fulfil their duty to ensure that employees have the access and entitlement to these proficiencies. To achieve this, it is fundamental that these technological competences are thoroughly defined and developed at any skill level or expenses and costs.

Education and Certification

To educate and produce i4.0 workers, it is vital that the skills sets, and the esoteric, explicit knowledge required to perform their jobs and work tasks in a *smart* working environment are clearly outlined and specified. This may entail a person requiring professional/trade certification or professional designation, to assure qualification to perform the duty. This attestation is typically granted by authorities in the field (third party), such as: professional societies; educational institutions (Further and Higher Education [FE] [HE]) for formal learning; or by private/public certificate-granting training agencies for non-formal learning. There is a duty to define, promote and support the certification and accreditation process of i4.0 job roles for businesses and FE/HE institutions on a regional, national, and transnational level.

Costs

One barrier to the deployment of i4.0 is the economic challenge of high costs, which include costs for hardware, software and infrastructure [34]. Even if technological advancements reduce the costs for embedded computing platforms steadily, the computation power and storage increase simultaneously. This particular challenge is amplified for Small and Medium Enterprises (SMEs) [35]. In order to help businesses and specifically SMEs grow and while adopting new digital technologies there is an obligation to provide them with government (national/local) backed financial support and

unfettered access to networked expertise via local chambers of commerce. In addition, a government programme of tax incentives to invest in the technological components of i4.0 is of paramount importance.

Table 3. A non-exhaustive list of Stakeholders and respective obligations for the Moral Concept of Risk and Reliability

Stakeholders: 4, 11 and 12
Moral Concept: Risks and Reliability

All technologies are used in a world where consumers, users, and the public rely on the services and resulted, automated process they support to work well; in fact, better. Computer professionals must become familiar with the inevitable risks associated with technology and address these in all stages of systems development. Choices among trade-offs in design and implementation will always involve ethical dimensions, and computing professionals should be prepared for them [19].

Standardisation

In order to fully integrate horizontally and vertically the value chains and to ensure a continuous data flow within, the entire automated systems environment must be thoroughly documented, based on globally recognized norms and quality standards for the sake interoperability in i4.0 [36]. There is little to no scope for different heterogeneous software tools, partial models and autonomously operating solution approaches within the broad field of industrial applications. The Reference Architecture Model Industry 4.0 (RAMI 4.0) and the Industry 4.0 Component both form the core pillars of i4.0 and serve as the basis for the development of networked products and services based on new business models. The interconnections between differing architecture models are essential in order to ensure future interoperability of the systems [36] and [37]. There are political challenges that deal with the lack of legal regulations [38]. For example, the IoT, a digital component of i4.0, creates cyber-security and other challenges such as the complex governance of global resources, unclear data ownership or data usage along with privacy concerns. Co-ordinated and harmonised legal regulations are fundamental in the formation of a foundation for the usage of IoT, affecting, for instance, security regulations or data usage between different organizations.

Rising Complexity

The technological evolution has significantly contributed to increasing complexity [39]. More specifically it rises from the heterogeneity of system components across differing technological domains which, in turn, are being integrated together. In a smart factory a considered source of risk is invoked by Human-Machine Interactions (HMI) and Human-Robot Interaction (HRI). Also, the increase of this intelligent equipment can lead to connecting the causes of human error with the “smart machine error”. The emerging risks from the use of intelligent machines, HMI and HRI need to be identified and characterized in order that these can be potentially mitigated in an i4.0 environment.

Security

There are inherent security vulnerabilities in supply chain systems, which can be exploited by attackers. The major vulnerability is in the top of the supply chain, reaching the rest of the organizational processes through its dependent actors [40]. Security is the *prime requirement* to transform a factory into a smarter factory and a supply chain into a smarter value chain; and this transformation is perceived as a major challenge for Industry 4.0, for sustainability initiatives in supply chains [41]. Therefore, there is an ethical duty on the designers and developers of systems and services: to explore and develop technologies for securing the next generation, decentralized, distributed and trusted industry environment while enhancing the job satisfaction and productivity of the industries.

Table 4. A non-exhaustive list of Stakeholders and respective obligations for the Moral Concepts of Privacy and Property Rights

Stakeholders: 3, 5, 6 and 8
Moral Concept: Privacy and Property Rights

Privacy expectations differ among individuals, cultures, and nations, and need to be taken into account in the design of computer-based systems [19]. Computing professionals need to be ready to participate in the public dialogue about privacy and security. Simple ethical issues of pirating of software or of straightforward copyright infringement are not the only concerns that computer professionals will have to deal within the area of digital/property rights management [19]. Computer and IT professionals need to practice in careful ethical thinking regarding property and human rights in a manner that avoids both simple legalism and naïve relativism.

Data Protection

Industry 4.0 technologies are heavily reliant on data-driven systems where various networked machines, sensors, facilities, and humans are interlinked through the Internet and exchange data with each other. With greater volumes of data come greater risks regarding systems vulnerability and people's confidentiality. Obviously, there are more opportunities for various cyber criminals to compromise data and plant malicious code. The risk of data leakage or loss is also rising in proportion to the volume [42]. In the design and development of cyber physical networks and data driven sustainable business models, legal issues pertaining to data privacy and protection must be considered.

Surveillance

There is a range of challenges as the fourth industrial revolution is rolled out in the workplace, including decreased quality of work for some in the labour market [31]. An example is how connected devices could be used to monitor workers in a way that can be construed as being intrusive, or to impinge on "out of hours" time such as evenings, holidays and weekends.

Property Rights

It is important to manage Intellectual Property (IP) in collaborative inter-organisational interconnected networks, which permit groups of companies, often competitors and/or customers, to share data and collaborate in the design, development and manufacture of complex products and/or services, exchanging large amounts of proprietary technical data. Therefore, in the implementation of Industry 4.0 the focus needs to be expanded in IP protection for intangible things, such as methodologies, configuration of virtual systems, data ownership, handling and storage, processing algorithms, brand recognition and other. There is a clear, sensitive balance that needs to be achieved between protecting IP, whilst at the same time facilitating the interoperability of process improvement in connected businesses. IP rights can be asserted in the drafting of contractual agreements in order to govern the data ownership rights in the operation and the inter-company relations [43].

4 Heuristics

A number of heuristics are suggested next which, if followed, may lead to ethical implementation of Industry 4.0. Each rule of thumb is substantiated by citing one or a number of the ethical normative principles, listed in Section 3, previously. Often there is a lack of relevant knowledge or experience in actors in a company's workplace. It should be made clear that it is the computer professional's moral and professional duty to instruct in such circumstances.

1) A New Regulatory Body: It is necessary to define a new international regulatory organisation that can bring together national communities to develop open standards (common and harmonised regulation, standardization and certification) to ensure the long-term growth of Industry 4.0. This body must also have a legislative capability in order to bring into line disparate laws concerning, for example, amongst other things: workers' rights, privacy and intellectual property. Ethical principles used to defend this heuristic are: [Deontology: Pluralism: Beneficence] and [Teleology: Utilitarianism].

2) Training New Skills/Certified Profession: Human Resources must be obligated to ensure that the training of new skills should be included in workers' learning curricula. In tandem academics and professional bodies should define and develop these technological competences that are required in the fourth industrial revolution, which will demand, for example, that computing/engineering studies at FE/HE should include these new skills in their curricula. The European Certification and Qualification Association (ECQA) currently provides a world-wide unified certification schema for numerous professions, supporting the definition and development of the knowledge (skill cards) required for job roles and assuring modularity of training and comparability in all over the world [44]. The ECQA could be the conduit for launching the certification and accreditation of the i4.0 Manager role. Ethical

principles used to defend this heuristic are: [Deontology: Pluralism: Beneficence] and [Teleology: Utilitarianism].

3) Conduct an Operational Feasibility Study: Automation is reshaping and impacting on working environments. An operational feasibility study can help determine how a system will be accepted by people by assessing employee resistance to change [45]. There is an ethical duty for the impact of i4.0 to be assessed, as an integral part of an operational feasibility study. In the first instance the study should determine how an i4.0 solution will be accepted by workers, especially at the operational level. This may imply dialogue between developers and trade unions, strategic and operational management. These trade union representatives have rights under the management regulations to be consulted by their employers and developers about anything affecting members, e.g. training, changes in working environment/patterns, job security, including the introduction and adoption of new technology. This may result in the negotiation of a policy for working with/alongside i4.0 technologies. Ethical principles used to defend this heuristic are: [Deontology (Pluralism): Beneficence and Non-injury], [Deontology (Contractarianism): The right to fair access to, and development of, communication resources] and [Teleology: Utilitarianism].

4) Conduct Risk Analysis and Management: In order that risks are managed effectively and efficiently, the hazards and effects associated with projects have to be properly managed [46]. Thus, a risk management plan needs to be prepared, as part of systems development, typically as a joint effort between project manager and system engineers, in order to document foreseen risks, estimate impacts, and define responses to issues. In order that lessons are learnt from the rising complexity of designing and deploying an i4.0 solution, a systematic recording and analysis of issues, errors, and failures must be carried out. In this all-important process and document should be the challenges and concerns of i4.0 that have been identified above. Ethical principles used to defend this heuristic are: [Deontology (Pluralism): Beneficence and Non-injury] and [Teleology: Utilitarianism].

5) Protection of Intellectual Property Rights: To govern the data ownership rights in the operation and the supply chain relations in the i4.0 environment, contractual agreements can include: the use of non-disclosure agreements, including the use non-disclosure clauses in employment and contractor contracts and use of confidentiality notices. Further proposals are that a business must always share only the necessary layers of information and ensure that adequate security measures/controls are in place [43]. Ethical principles used to defend this heuristic are: [Deontology (Pluralism): Self Improvement], [Deontology (Contractarianism): The human right to property and the human right to security] and the human right to privacy [Teleology: Egoism].

6) Formulate and Regulate Sensible Rules and Ethical Policies on Employee Surveillance: Examples of formulated policies include the “right to disconnect” and avoid checking or responding to emails in out-of-office hours [31]. Such measures would be a bid to improve employee wellbeing. For most employers, amongst many Human Resources (HR) policies and procedures will include IT and employee monitoring. There is an ethical duty that such guidelines must be formulated and authored with consultation with employees and workers associations. If policies exist then these must be edited, in discussion with staff, when new forms of workplace surveillance and monitoring are deployed. Ethical principles used to defend this heuristic are: [Deontology (Pluralism): Self Improvement], [Deontology (Contractarianism): The right to Privacy] and [The principle of Informed Consent].

7) National and Local Government Grants/Subsidies: The economic challenges in the implementation of i4.0 can be addressed by State interventions. The German Industry 4.0 policy initiative aimed at driving digital manufacturing forward through a EUR 200 million budget. This funding was one of the key drivers in the implementation of the strategy in the German manufacturing sector. This case is an exemplar of how the State (at both national and local levels) needs to financially support the investment required in realising i4.0 [47]. In Britain, the UK Research and Innovation (UKRI) Council is the national funding agency investing in science and research in the UK [48]. Thus, SMEs having access to grants/subsidies in the form of reduced costs, free equipment and/or cash awards to help in investing in the digital infrastructure, upskilling existing workforce is imperative. Ethical principles used to defend this heuristic are: [Deontology (Pluralism): Beneficence] and [Teleology: Utilitarianism].

8) General Data Protection in Smart Factories: General data protection is a matter valid for workers in the digital era in general, but they are somehow exacerbated in the Industry 4.0 Smart Factory context, due to the increased interaction between men and machines and to the introduction of new technologies, such as wearables used in the workplace. The ethical principle that can be used to defend this heuristic is: [Deontology (Pluralism): Non-Injury] and [Deontology (Contractarianism): The right to Privacy].

9) Drive Towards Global Standards in Security: Even if sections of a smart factory are kept in a segmented network or completely free of an internet connection, security liability still exists. The

i4.0 topology, which integrates the IT, operational technology and intellectual property assets make the security issue more acute. There is an ethical duty to secure i4.0 manufacturing companies by demanding that they align with global standards, e.g., the IEC 62443 cybersecurity standard in order to address and mitigate current and future security vulnerabilities in industrial automation and control systems. Likewise, the National Institute of Standards and Technology (NIST) voluntary Cybersecurity Framework is based on existing standards, guidelines, and best practices [49]. Moreover, there is a need for deploying a conceptual framework for privacy protection even in 'necessary' surveillance because every human has the right to privacy [50]. What is vital is that IT administrators, operational technology engineers, production staff, management, in other words all parties, speak a single universal language regarding privacy and security, since these two are interconnected. The ethical principles that can be used to defend this heuristic are: [Deontology (Pluralism): Non-Injury] and [Deontology (Contractarianism): The right to Security].

5 Conclusions and Future Research

The objective of applying the ethical framework presented in this paper was to identify and defend ethical stances that can, and should be, taken into account in the development and quality deployment of Industry 4.0. In so doing, the authors conclude that the importance of ethical considerations in the strategic and operational decision making concerning i4.0 can be brought to the attention of: IT administrators, operational technology engineers, production workers, senior level executives from manufacturing sector, government agencies and other; thus, help raise the visibility and applicability of sensible and realistic ethical principles in use. This application case study contributes to the current ethical and philosophical discourse relating to i4.0. In particular, a set of heuristics for ethical guidance has been proposed which, in turn, will raise the awareness of the moral issues, and help as a practical guide for developers and end-users of the smart factories. The set of heuristics presented in this paper is argued to be a realistic and balanced approach for involved stakeholders parties interests and concerns. For some of these suggested rules UK law clearly applies (e.g. IP, Privacy and Health & Safety at Work legislations) and leads directly to the appropriate ethical conclusion(s). But to rely solely on law as a moral guideline is clearly dangerous because it may lead to occasions where individuals fail to accomplish their ethical responsibility.

Additional future research could include interweaving the issues of Industry 4.0 into the systems development life cycle (SDLC). Thus, at each stage of the process for planning, designing, creating, testing, and deploying information technology, operational technology and intellectual property assets, i4.0 designers and developers will be conscious of the professional duty they have to incorporate ethics into the system's specification and design. Further research in this field is needed relating to SMEs and micro companies where, as far as we know, only very few IT professionals are being employed. The formal education [51] and organisational learning of the IT professionals [52] are of paramount importance for their ethical decision making and for the quality improvement of the software process itself. The recent events relating to the global coronavirus pandemic resulted in the development of many technocratic machine learning systems of governance to be deeply implicated in the social production and distribution of risk. Apparently, the role of machine learning in the production of risk must be re-considered by engineers and other technologists. In [53] the authors describe the effort to institutionalize ethics in the technology industry and emphasise the need to develop a deeper understanding of the social production of risk and its management.

Software Process Improvement (SPI) is core to the modern engineering of complex systems, such as Industry 4.0 solutions. In order that SPI works, a manifesto was formulated and published [54], which governs personal behaviour in relation to Software Process Improvement work. The proposed heuristics for ethical i4.0 solutions resulting in technological change, social change and changes in the business paradigm, which are all morally justifiable, can also be understood in the context of the three values espoused by the SPI Manifesto: *People* (Must involve people actively and affect their daily lives); *Business* (Is what you do to make business successful); and *Change* (Is inherently linked with change). The focus of this paper has been in the strategic formulation and operational delivery of i4.0 solutions for the business, the worker and society. The participants in this process must always be conscious of the ethical outcome of decisions made because of the impact they have in affecting working environments, workers' lives and the wider inherent changes in society.

References

1. Marr, B. (2018) Why Everyone Must Get Ready For The 4th Industrial Revolution, Available from Forbes at: https://www.forbes.com/sites/bernardmarr/2016/04/05/why-everyone-must-get-ready-for-4th-industrial-revolution/#5af877b33f90 [date accessed: 12th January 2021]
2. Sharman, J. (2018) Four phases of industrial revolution, Available at: https://www.thenbs.com/knowledge/four-phases-of-industrial-revolution-phase-one [date accessed: 12th January 2021]
3. Hermann, M., T. Pentek, and B. Otto. (2016) Design Principles for Industrie 4.0 Scenarios, Proceedings of 2016 49th Hawaii International Conference on Systems Science, January 5–8, Maui, Hawaii. doi:10.1109/HICSS.2016.488.
4. Lu, Y. (2017) Industry 4.0: A Survey on Technologies, Applications and Open Research Issues, Journal of Industrial Information Integration 6: 1–10. doi:10.1016/j.jii.2017.04.005
5. Gökalp E., Şener U. and Eren P.E. (2017) Development of an Assessment Model for Industry 4.0: Industry 4.0-MM. In: Mas A., Mesquida A., O'Connor R., Rout T., Dorling A. (eds) Software Process Improvement and Capability Determination. SPICE 2017. Communications in Computer and Information Science, vol 770. Springer, Cham. https://doi.org/10.1007/978-3-319-67383-7_10
6. Varoufakis, Y (2018) Marx predicted our present crisis and points the way out, Available from the Guardian at: https://www.theguardian.com/news/2018/apr/20/yanis-varoufakis-marx-crisis-communist-manifesto [date accessed: 12th January 2021]
7. Marx, K. and Engels, F. 3rd edition (1977) Manifesto of the Communist Party, Peking: Foreign Languages Press
8. Erboz, G. (2017) How To Define Industry 4.0: Main Pillars Of Industry 4, 7th International Conference on Management, (Nitra, Slovakia), 1st -2nd June 2017, Available at: https://www.researchgate.net/publication/326557388_How_To_Define_Industry_40_Main_Pillars_Of_Industry_40 [date accessed 13th January 2021]
9. Alcácer, V. and Cruz-Machado, V. (2019) Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems, Engineering Science and Technology an International Journal, Vol 22 (3), pp 899-919
10. Xua, L.D., Xub, E. L. and Lia, L. (2018) Industry 4.0: state of the art and future trends, International Journal of Production Research, Vol. 56 (8) pp. 2941–2962
11. Geissbauer, R., Vedso, J. and Schrauf, S. (2016) Industry 4.0: Building the digital enterprise, Available from PWC at: https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf [date accessed: 13th January 2021]
12. Birgün, S. (2017) A software Development Process Improvement Study to `support Compatibility with Industry 4.0 for software Makers, in the Proceedings of the International Symposium for Production Research - ISPR, 13-15 September 2017, Vienna, Austria, pp 273-283
13. Pries-Heje, J. and Johansen, J. (Eds) (2010) SPI Manifesto, Available at: https://2021.eurospi.net/images/eurospi/spi_manifesto.pdf [date accessed: 25th May 2021]
14. Georgiadou, E., Siakas, K., Estdale, J., Berki, E., & Ross, M. (2019a). *A Comparison of Two Manifestos: Agile and SPI*. Paper presented at International Experiences and Initiatives in IT Quality Management, 15 April 2019, Southampton, UK.
15. Georgiadou, E., Siakas, K., Berki, E., Estdale, J., Rahanu, H. and Ross, M. (2019b) A Comparison of Two Manifestos: Agile and SPI, Proceedings of the 26th European Conference, EuroSPI 2019: Systems, Software and Services Process Improvement, 18-20 Sept 2019, Edinburgh, UK, pp. 209-221, Springer
16. Johnson, D. (1995) Computers, ethics and social values New Jersey: Prentice-Hall Inc.
17. Kallman, E.A. and Grillo, J.P. (1996) Ethical Decision Making and Information Technology: An Introduction with Cases, New York: McGraw-Hill Inc.
18. Spinello, R.A. (1995) *Ethical Aspects of Information Technology* Englewood Cliffs, New Jersey: Prentice-Hall, Inc.
19. Huff, C., Anderson, R.E., Little, J.C. (1995) Integrating the ethical and social context of computing into the CS curriculum: An Interim Report from the Content Subcommittee of the Impact CS Steering Committee, In Proceedings of ETHICOMP 95: An International Conference on the Ethical Issues of Using IT, Leicester UK, 28-30 March, 2, pp. 1-19.
20. Rahanu, H., Georgiadou, E., Siakas, K. V. and Ross, M (2019) Health, safety and wellbeing through ethical behaviours in computer and information systems development and deployment. Journal of Software: Evolution and Process. ISSN 2047-7481 (doi:10.1002/smr.2225)
21. Kiel, D., Müller, J.M., Arnold, C. and Voigt, K. (2017) Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0, International Journal of Innovation Management, Vol. 21 (8), https://doi.org/10.1142/S1363919617400151

22. Luthra, S. and Mangla, S.K. (2018) Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies, Process Safety and Environmental Protection, Vol 117, pp 168-179, https://doi.org/10.1016/j.psep.2018.04.018
23. Schneider, P. (2018) Managerial challenges of Industry 4.0: an empirically backed research agenda for a nascent field. Review of Managerial Science, 12, pp 803–848. https://doi.org/10.1007/s11846-018-0283-2
24. Chen, B., Wan, J., Shu, L., Li, P., Mukherjee, M. and Yin, B. (2017) Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges, in IEEE Access, vol. 6, pp. 6505-6519, DOI: 10.1109/ACCESS.2017.2783682
25. El Hamdi, S., Abouabdellah, A. and Oudani, M. (2019) Industry 4.0: Fundamentals and Main Challenges, 2019 International Colloquium on Logistics and Supply Chain Management (Montreuil - Paris, France), 12th -14th June 2019, Available from IEEE Xplore at: https://ieeexplore.ieee.org/document/8907280/authors#authors [date accessed: 14th January 2021]
26. Erro-Garcés, A. (2019) Industry 4.0: defining the research agenda, Benchmarking: An International Journal, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/BIJ-12-2018-0444
27. Machado, C. G., Winroth, M., Carlsson, D., Almström, P., Centerholt, V. and Hallin, M. (2019) Industry 4.0 readiness in manufacturing companies: challenges and enablers towards increased digitalization, Procedia CIRP, Vol 81, pp 1113-1118, https://doi.org/10.1016/j.procir.2019.03.262
28. Mendelow, A. L. (1981) Environmental Scanning--The Impact of the Stakeholder Concept, ICIS 1981 Proceedings. 20 Available at: http://aisel.aisnet.org/icis1981/20 [date accessed: 17th January 2021]
29. Ross, R. (1970) Obligation, Ann Arbor: The University of Michigan Press. ISBN 0472087657
30. Schwab, K. (2017) The Fourth Industrial Revolution, Portfolio Penguin, ISBN-13: 978-0241300756
31. Corfe, S. (2018) 4IR in the Workplace: Ensuring Employers and Employees Benefit, London: Social Market Foundation, ISBN: 978-1-910683-52-1
32. Romero, D., Bernus, P., Noran, O., Stahre, J. and Fast-Berglund, Å. (2016), "The operator 4.0: human cyber-physical systems & adaptive automation towards human-automation symbiosis work systems", Advances in Production Management Systems, Springer, Cham, pp. 677-686.
33. Sivathanu, B. and Pillai, R. (2018) "Smart HR 4.0 – how Industry 4.0 is disrupting HR", Human Resource Management International Digest, Vol. 26 No. 4, pp. 7-11.
34. Birkel, H. S. and Hartmann, E. (2019) Impact of IoT challenges and risks for SCM, Supply Chain Management, Vol. 24, pp 39–61, ISSN: 1359-8546
35. Neirotti, P., Raguseo, E. and Paolucci, E. (2018) How SMEs develop ICT-based capabilities in response to their environment: past evidence and implications for the uptake of the new ICT paradigm, Journal of Enterprise Information Management, Vol. 31 (1), pp. 10-37.
36. Schulz, T. and Stark, A. (2019) Standardization in Industry 4.0, Available at: https://www.spotlightmetal.com/standardization-in-industry-40-a-826918/ [date accessed: 21st January 2021]
37. Itasse, S. and Seit, J. (2017) USA: Industry 4.0 the American Way, Available at: https://www.spotlightmetal.com/usa-industry-40-the-american-way-a-673998/ [date accessed: 21st January 2021]
38. Leone, L. (2017) "Beyond connectivity: the internet of food architecture between ethics and the EU citizenry", Journal of Agricultural and Environmental Ethics, Vol. 30 No. 3, pp. 423-438.
39. Brocal, F., González, C., Komljenovic, D., Katina, P. F. and Sebastián, M. A. (2019) Emerging Risk Management in Industry 4.0: An Approach to Improve Organizational and Human Performance in the Complex Systems, Complexity in Manufacturing Processes and Systems 2019, Available at: https://doi.org/10.1155/2019/2089763 [date accessed: 21st January 2021].
40. Luthra, S. and Mangla, S.K. (2018) Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies, Process Safety and Environmental Protection 117, DOI: 10.1016/j.psep.2018.04.018.
41. Pereira, T., Barreto, L. and Amaral, A. (2017) Network and information security challenges within Industry 4.0 paradigm, Procedia Manufacturing, Vol. 13, pp. 1253-1260.
42. Tyrrell, M. (2019) Data-driven Industry 4.0 technologies could breach GDPR rules, Available from Production Engineering Solutions at: https://www.pesmedia.com/fourth-industrial-revolution-gdpr-data-breach-irwin-mitchell/ [date accessed: 23rd January 2021].
43. Soares, M. and Kauffman, M. (2018) Industry 4.0: Horizontal Integration and Intellectual Property Law Strategies In England, Revista Opinião Jurídica (Fortaleza), Vol 16 (23), pp268-289.
44. ECQA (2020) European Certification and Qualification Association (ECQA), Available from the ECQA at: http://www.ecqa.org/index.php?id=158&no_cache=1 [date accessed: 24th January 2021].

45. Stair, R. and Reynolds, G. (2017) Fundamentals of Information Systems, Cengage Learning, 9th Edition.
46. PMI (2013) A Guide to the Project Management Body of Knowledge (PMBOK Guide), Project Management Institute; 5th edition.
47. Klitou, D., Conrads, J. and Rasmussen, M. (2017) Germany Industrie 4.0, Available from EU Digital Transformation Monitor at: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf [date accessed: 25th January 2021].
48. UKRI (2019) UK Research and Innovation, Available from UKRI at: https://www.ukri.org/?_ga=2.41519138.1801479253.1590657311-185467581.1588849972 [date accessed 25th January 2021]
49. NIST (2016) Cybersecurity Framework, Available from the National Institute of Standards and Technologies at: https://csrc.nist.gov/News/2014/Cybersecurity-Framework [date accessed: 25th January 2021].
50. Chaudhary, S., Berki, E., Nykänen, P., Zolotavkin, Y., Helenius, M. and Kela, J. (2016). Towards a Conceptual Framework for Privacy Protection in the Use of Interactive 360 degrees Video Surveillance. *IEEE Proceedings of the 22nd International Conference on Virtual System & Multimedia (VSMM), Oct 2016, Malaysia.* (http://ieeexplore.ieee.org/document/7863179/).
51. Valtanen, J., Tiensuu, A., Berki, E. and Kavde-Datye, N. (2014). Reflections on the quality of formal and informal learning. In the Proceedings of Uhomoibhi, J., Linecar, P., Barikzai, S., Ross, M. & Staples, G. (Eds) *INSPIRE XIX Global issues in IT education*. The 19th INSPIRE International Conference on Software Process Improvement Research, Education & training. Southampton, UK, 5/2014, pp 107-122.
52. Ahlgren, R., Pulkkinen, M., Berki, E. and Forsell, M. (2006). Using Groupware Technologies to Facilitate Organisational Learning and Software Process Improvement – A Case Study. Messnarz, R., Richardsson, I. et al. (Eds) *European Systems and Software Process Improvement and Innovation*. *Proceedings of European Software Process Improvement (EuroSPI) 2006* Conference, 11-13 Oct. Joensuu, Finland. Pp. 2.1-2.7, John Wiley & Sons Ltd.
53. Moss. E., Metcalf J. (2020) High Tech, High Risk: Tech Ethics Lessons for the COVID-19 Pandemic Response, Available from Cell Press, Open Access at: https://www.cell.com/patterns/pdf/S2666-3899(20)30136-7.pdf [date accessed: 7th February 2021].
54. Messnarz, R., Sicilia, M. A., Biro, M., Garcia Barriocanal, E., G. Rubio, M., Siakas, K., & Clarke, A. (2014) Social responsibility aspects supporting the success of SPI, Journal of Software: Evolution and Process, 26(3), 284-294.